Published in final edited form as:
J Appl Gerontol. 2015 April ; 34(3): 329–342. doi:10.1177/0733464812471894.

Improving the Validity of Activity of Daily Living Dependency Risk Assessment

Daniel O. Clark[1,2,3], **Timothy E. Stump**[4], **Wanzhu Tu**[2,4], and **Douglas K. Miller**[1,2,3]

[1]Indiana University Center for Aging Research, Indianapolis IN, USA

[2]Regenstrief Institute, Inc., Indianapolis IN, USA

[3]Department of Medicine, Division of General Internal Medicine and Geriatrics, Indiana University School of Medicine, Indianapolis IN, USA

[4]Division of Biostatistics, Indiana University School of Medicine, Indianapolis IN, USA

Abstract

Objectives—Efforts to prevent activity of daily living (ADL) dependency may be improved through models that assess older adults' dependency risk. We evaluated whether cognition and gait speed measures improve the predictive validity of interview-based models.

Method—Participants were 8,095 self-respondents in the 2006 Health and Retirement Survey who were aged 65 years or over and independent in five ADLs. Incident ADL dependency was determined from the 2008 interview. Models were developed using random 2/3rd cohorts and validated in the remaining 1/3rd.

Results—Compared to a c-statistic of 0.79 in the best interview model, the model including cognitive measures had c-statistics of 0.82 and 0.80 while the best fitting gait speed model had c-statistics of 0.83 and 0.79 in the development and validation cohorts, respectively.

Conclusion—Two relatively brief models, one that requires an in-person assessment and one that does not, had excellent validity for predicting incident ADL dependency but did not significantly improve the predictive validity of the best fitting interview-based models.

Keywords

activities of daily living; gait speed; cognitive impairment; disability

Corresponding Author: Daniel O. Clark, PhD, Associate Professor of Medicine, Regenstrief Institute, Inc., 410 West, 10th Street, Suite 2000, Indianapolis IN 46202, USA. daniclar@iupui.edu.

Authors' Note
All authors contributed to the study concept and design, data analysis and interpretation of data, and preparation of manuscript. None of the authors has any conflicts of interest to report.

Declaration of Conflicting Interests
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author Manuscript
Author Manuscript
Author Manuscript

Introduction

The complexities and costs of caring for a dependent elder are substantial. Older adults dependent in activities of daily living (ADL) are among the highest cost Medicare beneficiaries (Lewin Group, 2010) and among those most at risk for nursing home placement (Gaugler et al., 2007). Identifying those at high risk of becoming dependent in activities of daily living (ADL) is an important step in efficiently preventing dependence and the associated high cost care. Improved identification of dependency risk could lead to improved targeting of research protocols and clinical care programs, especially if the identification system pinpoints where (and how) to intervene.(Sarkisian et al., 2000)

Disability is defined as having difficulty with an activity and, in disability models, precedes dependence, which is defined as receiving help from another person to complete an activity.(Gill, Robison, & Tinetti, 1998) Physical performance measures have shown promise in predicting both ADL disability(Haung, Perera, VanSwearingen, & Studenski, 2010; Viccaro, Perera, & Studenski, 2011) and dependence.(Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995) Although some performance-based measures lack brevity and require significant equipment and space, gait speed is simple and brief(Cesari, 2011) and has been recommended as a possible screening tool.(Cesari et al., 2005; Van Kan et al., 2009) In direct comparisons of gait speed to other physical performance measures, gait speed performed essentially as well as the Timed Up and Go Test and nearly as well as the longer Short Physical Performance Battery and Berg Balance Scale in predicting ADL disability(i.e., difficulty) at 6, 12, and 18 months.(Haung et al., 2010; Viccaro et al., 2011) The c-statistics for gait speed's prediction of 12-month incident ADL disability in clinic-based samples of older adults were 0.797 (N = 110; Haung et al., 2010) and 0.835 (N = 457; Viccaro et al., 2011) This indicates excellent validity for predicting incident disability. However, conceptual models of disability incidence suggest that cognitive impairment is also important to ADL disability and dependence and should be considered in predictive models along with physical impairment. (Institute of Medicine, 2007)

Predictive models of ADL disability or dependency based on self- or proxy- interview data also have been published.(Chaudhry et al., 2010; Covinsky, Hilton, Lindquist, & Dudley, 2006; Min et al., 2009; Sarkisian et al., 2000) These have achieved very good predictive validity (i.e., c-statistics 0.69, 0.76, and 0.77) but none has quite achieved a level of predictive validity that would be considered excellent (i.e., c-statistic ≥0.8).(Ohman, Granger, Harrington, & Lee, 2000) Similar to physical performance measures, these interview tools have given limited weight to explicit measures of cognitive impairment. Sarkisian et al. (2000) did find cognitive function to be predictive of ADL disability but excluded it from their scoring tool due to their focus on modifiable predictors. Covinsky et al. (2006) evaluated a few cognitive measures as candidates for their ADL dependency prediction model but the final model included only one item (remembering the U.S. Vice President's name) and a functional task that involves cognition (i.e., managing money; Covinsky et al., 2006).

Recent research highlights the critical role of cognitive impairment in ADL disability. For example, in identifying types of ADL trajectories in the last year of life, Gill and colleagues identified five common trajectories.(Gill, Gahbauer, Han, & Allore, 2010) Trajectory type was not associated with condition leading to death other than advanced dementia which was associated with persistent severe ADL disability. Within person variability also points to a particularly important role of cognitive impairment. For example, a recent study showed that a majority of older adults who experienced three or more months of ADL disability recovered but recovery was short-lived and less likely among those with cognitive impairment.(Hardy & Gill, 2004) In fact, two thirds of individuals with advanced dementia have persistent severe disability.(Gill et al., 2010).

We used a nationally representative sample of community dwelling older adults to test the hypotheses that the addition of (1) cognitive status indicators and (2) gait speed to an existing interview-based model would significantly improve prediction of incident ADL dependency. Following convention, we rated an improvement of 0.05 in the c-statistic as significant improvement. For the interview model, we elected to work from measures in the Covinsky index due to the authors' comprehensive evaluation of candidate items, its brevity, and their focus on predicting ADL dependency. This is also the best performing interview-based model with c-statistics of 0.77 (Covinsky et al., 2006) and 0.79 (Clark, Stump, Tu, & Miller, 2012). We explored models with and without gait speed because in some situations performance-based measures are not feasible (e.g., telephone surveys or busy primary care sites). Also, in an effort to maintain brevity, we explored available dimensions of cognitive impairment separately, for example, short-term memory, working memory, speed of processing, and orientation. These dimensions may not have the same impact on ADL dependency. One study showed that short-term memory and orientation dimensions were particularly important in predicting ADL dependency.(Gill, Williams, Richardson, Berkman, & Tinetti, 1997) In fact, memory (repetition and recall) and orientation make up 14 of the 16 points in the new assessment tool "Sweet 16," which is highly correlated with longer measures of impaired cognition (Fong et al., 2010).

Method

Sample

Data came from the public use version of the Health and Retirement Study (HRS). The HRS is a panel study with a multistage area probability sample (Hauser & Willis, 2004). There is a 100% oversample of blacks and Hispanics. New age cohorts have been added since the original sample in 1992. Using HRS- supplied sampling weights, the cohort is nationally representative. There were 8,796 self-respondents who were aged 65 years or over at the 2006 primary interview and independent in five ADLs with complete data on the interview model independent variables. Two-year incident ADL dependence was determined from the 2008 self-respondent or proxy interviews. HRS sampling weights were used for the incident rate calculation. There were 257 persons missing at 2008 follow-up and another 444 who had died by 2008.

For the performance-based model we used an HRS subsample in which gait speed was assessed. In 2006, a random one-half sample of HRS participants was selected for an enhanced face-to-face interview. Respondents selected for the enhanced interview who resided in a nursing home or required a proxy respondent were not asked to complete the gait speed measure. Gait speed was completed on 4,076 HRS respondents; 578 were selected for the enhanced interview but did not complete the walk test. Of the 4,076, 3,506 (86%) were independent in basic ADLs in 2006, had complete data on our variables of interest, and had a self or proxy-report of 2008 ADL status.

Measures

ADL dependence—Dependence is defined as receiving help from another person (use of an assistive device by itself does not constitute dependency) to complete the activity. We included five basic ADLs: bathing, dressing, eating, toileting, and transferring from a bed to a chair. We defined ADL dependency as a report of receiving help in any one of the five ADLs at the 2008 interview.

Interview measure—To generate a Covinsky index score for self-respondents, we included the nine predictor variables reported in Covinsky et al. (2006). These were age 80 years or more, diagnosis of diabetes, inability to name the vice president, a fall in the past year, and low body mass index (BMI). A respondent is considered to have low BMI if their BMI is one standard deviation below the mean for their gender in this sample. Also among the nine predictor variables was difficulty lifting 10 pounds, difficulty walking several blocks, needing help with finances, and difficulty bathing or dressing. Each risk factor is assigned one point and the score ranges from zero to nine. For each of these variables, the HRS 2006 wording and response options are identical to those of the 1998 Assets and Health Dynamics of the Oldest Old survey used by Covinsky et al. (2006).

Physical performance measure—Gait speed was completed on a 2.5 meter course in the participant's home in a noncarpeted area when available. The participant began with their feet at a starting line and the timing began when the first foot landed on the floor across the start line. Two trials were completed. Taking the mean of the two trials, we recoded gait speed into quartiles based on performance.

Cognitive status index—To determine cognitive status, we followed a 27-point cognitive index developed from HRS interviewer-administered items and validated using the 2001–2003 Aging, Demographics, and Memory Study (ADAMS). ADAMS was a substudy of the HRS that completed an extensive in-home neuropsychological and neurological assessment on a subsample of 856 HRS respondents. The cognitive index was validated by comparing the distribution of normal, cognitive impairment/no dementia (CIND), and dementia based on the ADAMS diagnostic assessments to those based on the 27-point HRS score.(Langa, Kabeto, & Weir, 2009) The 27-point cognitive index includes (1) an immediate and delayed 10-noun free recall test to measure short-term memory; (2) a serial seven subtraction test to measure working memory; and (3) a counting backward test to measure speed of mental processing. Delayed recall cannot be scored in an interview without first conducting an immediate recall test. Thus, to best address our aim of a simple risk assessment tool, we included separate variables for immediate and delayed recall and evaluated whether the delayed recall score adds substantive value beyond that of immediate recall in the prediction model. Finally, because prior research has shown the importance of orientation, we incorporated a fourth domain based on an orientation measure developed from self-respondents' ability to identify the month, day, year, and day of the week. The scoring procedures for cognitive measures are shown in Table 1.

Analyses

We split the full sample into a random 2/3rd "development" cohort (*n* = 5,587) and a random 1/3rd "validation" cohort (*n* = 2,867); in the enhanced interview sample these sample sizes were *n* = 2,316 and *n* = 1,190, respectively. In step one, using the development cohort, we assessed the interview items and the four cognitive dimensions for their ability to predict incident ADL dependence using backward elimination; excluding from the model variables with a *p*-value of greater than 0.05. We calculated the receiver operating characteristic curves (ROC), also known as the c-statistic, for the discrimination of the considered models. A difference of 0.05 or greater in the models' c-statistics was selected as an indication of significance. We also assessed the interview items in a backward elimination model in the enhanced interview dataset with and without gait speed and with and without cognitive measures. The most parsimonious models with high c-statistic values were selected. In step two, we performed a logistic regression analysis of the models from step one using the validation cohort. Finally, in step three, we created scores for the independent variables in the models using the odds ratios obtained in the development cohorts from step one. In creating scores, we rounded odds ratios to the nearest whole number. After computing each person's score, we assessed clinical utility by completing a logistic regression model in the 1/3rd validation cohort. For a sensitivity analysis of the influence of attrition due to death, we included in the determination of 2008 ADL dependency status proxy reports of ADL dependency status in the three months prior to death. There were 359 (81% of those who died) "exit" reports available for this sensitivity analysis in which we reran all models.

Results

Table 1 presents descriptive data. The weighted 2-year ADL incidence rates for the development and validation cohorts were 4.87 and 4.62, respectively. In both cohorts, mean age was 74 years, a slight majority was female, 12% were Non- Hispanic black, and 7% to 8% were Hispanic. Twenty-nine percent had had a hospital stay, nearly 2/3rd had hypertension, about 2/3rd had arthritis, 1/4th had noncongestive heart failure heart disease, and 1/5th had diabetes. Almost 1/3rd reported difficulty walking several blocks yet a majority scored 1 or less on the Covinsky score indicating a very low risk of ADL dependency. About three percent scored very low on orientation (two or fewer correct) and immediate word recall (2 or fewer words recalled). Gait speeds for each of the quartiles in the development and validation cohorts are shown in Table 1. The slowest quartile had a gait speed of less than 0.59 meters per second.

In Table 2, results from the backward regression for the interview model in the development cohort are shown. The Covinsky items that stayed in the model were age 80 years or more, diagnosis of diabetes, difficulty walking several blocks, difficulty bathing or dressing, and needing help managing money. In regard to cognitive items, orientation and immediate and delayed recall were retained in the backward elimination process. In our evaluation of delayed recall, we found that the c-statistic does not change appreciably with or without the score. Thus, our simplest model excludes delayed recall and contains seven variables and has a c-statistic of 0.815.

Backward elimination in the development cohort of the enhanced interview sample using only the Covinsky items and cognitive measures resulted in the odds ratios and c-statistic shown in the 3rd column of Table 2. This model did not include gait speed. When we included gait speed in the backward elimination the c-statistic improved from 0.812 to 0.834. This latter model has four interview variables (age, difficulty walking, difficulty bathing or dressing, and immediate word recall) and gait speed. Gait speed alone (not shown) had an odds ratio of 5.90 (3.83–9.08; for the slowest quartile compared to all others) and a c-statistic of 0.704.

Our seven item interview model and five item model with gait speed were then examined in the validation cohort (Table 3). The parameter estimates were similar to those obtained in the development cohort and the c-statistics were 0.801 in the interview model and 0.791 in the model with gait speed. By rounding to the nearest whole number the odds ratios from the analyses in the development cohort, we created a scoring system for the variables. The variable scores are shown in columns two and four of Table 4. When the scored variables were used in a logistic regression model to predict incident ADL in the validation cohort, the resulting c-statistics were 0.801 for the interview model and 0.784 for the model with gait speed.

To assess the influence of attrition due to death on our results we ran the models of Table 2 in our development cohort dataset with proxy exit interviews included. These proxy exit interviews included questions about ADL status in the 3 months prior to death. Including the 255 proxy interviews with complete ADL data in our development cohort gave model fit results consistent to what we have presented for both the primary and enhanced interview datasets.

Discussion

In a prior publication, the Covinsky items in this same dataset without the cognitive measures had a c-statistic of 0.79 in the validation cohort (Clark et al., 2012). As a general rule of thumb, a c-statistic of 0.7 to 0.79 is considered very good and 0.8 or greater is considered excellent (Ohman et al., 2000). Our results indicate that incorporating cognitive status assessments into this existing ADL prediction score brought that score up modestly and into the range of excellent. However, the c-statistic did not improve by a minimum of 0.05 which was the improvement level we set as evidence of model improvement.

Whether the added questions for cognitive assessment are worth the increased predictive validity is a question of time and cost. Trained personnel are needed to administer a telephone cognitive assessment and patients may be wary of completing an assessment on the telephone. Nevertheless, we were able to simplify the existing score and produce a final risk scoring tool that has seven items. In a clinical encounter, delivering this ADL dependency risk tool would be simple and low cost and might uncover valuable information given that many primary care providers are unaware of their patients' cognitive status (Boustani et al., 2005).

In a face-to-face encounter, the combined interview and gait speed model appears to be quite valid as well. It had a high c-statistic in the development cohort and incorporates both cognitive impairment and physical performance testing; domains of significant importance in the care and management of older adults. In validation analyses, this model's c-statistic dropped to 0.79 to 0.78, which may be related to less precise estimates in the smaller sample size in the validation cohort of the enhanced interview subsample. But, again, there are trade-offs. For physical assessment (i.e., gait speed), patients need to come in to the office, and requiring that they do so for a screening effort would decrease participation. A very small improvement in area under curve (AUC) may not be worth the loss of patient participation.

At this point, using this tool in clinical practice for patient counseling about ADL dependency risk would not be appropriate given the stress associated with knowledge of risk and the relative imprecision of that risk when applied to an individual. Future research should validate this tool in clinical populations prior to applying this tool for individual-level decisions about care.

With our attention to cognition, the exclusion of baseline proxy interviewees has a potentially significant effect on our findings. There were 961 proxy interviews at baseline. However, 51% of these proxy interviewees were ADL dependent at baseline—versus 7.4% of self-respondents. Of the 469 proxy interviewees who were ADL independent at baseline, 26.6% were either dependent or deceased (13.4% dependent and 13.2% deceased) at 2-year follow-up—versus 11.0% of self-respondents (5.2% dependent and 5.8% deceased). Thus, needing a proxy interview is itself a substantial risk factor for ADL dependence [or death]. A limitation of our analysis is that although all participants were self-respondents at baseline, a proxy respondent was needed to determine incident ADL dependency for 2% of respondents. The impact of this change in respondent on our estimates is likely minimal due to our focus on the observable status of needing assistance from others and our focus on incident ADL dependency rather than severity of ADL dependency.

In sum, validation of these brief models in a clinical population, rather than a community-based survey sample, is needed to be certain of their utility. Should such validation support the findings presented here, this approach could become a cost-effective method of risk-stratifying older adults for incident ADL dependency. Such risk stratification would allow for improvements in targeting for geriatric randomized trials and could improve targeted implementation of evolving geriatric models of care.

Acknowledgments

Funding: The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by National Institute on Aging grants P30 AG024967 and R01 AG031222. The sponsor (National Institute on Aging) had no role in the design, methods, data analysis, or preparation of the article.

Biographies

Daniel O. Clark is co-director of the IU-Roybal Center for translational research in self-management among vulnerable older adults. His main interests are in defining vulnerability and designing programs to address vulnerability.

Timothy E. Stump is a statistician who has been working with large nationally representative databases for nearly 20 years. His primary expertise is in cohort studies of aging.

Wanzhu Tu is a biostatistician. Dr. Tu has extensive experience in aging research and particular expertise in the analysis of cost data.

Douglas K. Miller is co-director of the IU Center for Aging Research and a geriatrician. He has extensive experience in the management and analysis of cohort studies of aging.

References

Boustani M, Callahan CM, Unverzagt FW, Austrom MG, Perkins AJ, Fultz BA, Hendrie HC. Implementing a screening and diagnosis program for dementia in primary care. Journal of General Internal Medicine. 2005; 20:572–577. [PubMed: 16050849]

Cesari M. Role of gait speed in the assessment of older patients. [Comment Editorial]. Journal of American Medical Association. 2011; 305(1):93–94.10.1001/jama.2010.1970

Cesari M, Kritchevsky SB, Penninx BW, Nicklas BJ, Simonsick EM, Newman AB, Pahor M. Prognostic value of usual gait speed in well- functioning older people—results from the Health, Aging and Body Composition Study. [Research Support, N.I.H., Extramural]. Journal of American Geriatrics Society. 2005; 53:1675–1680.10.1111/j.1532-5415.2005.53501.x

Chaudhry SI, McAvay G, Ning Y, Allore HG, Newman AB, Gill TM. Geriatric impairments and disability: The cardiovascular health study. Journal of American Geriatrics Society. 2010; 58:1686–1692.10.1111/j.1532-5415.2010.03022.x

Clark DO, Stump TE, Tu W, Miller DK. A comparison and cross- validation of models to predict basic activity of daily living dependency in older adults. Medical Care. 2012; 50:534–539. [PubMed: 22581013]

Covinsky KE, Hilton J, Lindquist K, Dudley RA. Development and validation of an index to predict activity of daily living dependence in community-dwelling elders. Medical Care. 2006; 44(2):149–157. doi: 00005650-200602000-00008 [pii]. [PubMed: 16434914]

Fong TG, Jones RN, Rudolph JL, Yang FM, Tommet D, Habtemariam D, Inouye SK. Development and validation of a brief cognitive assessment tool: The sweet 16. Archives of Internal Medicine. 2010 doi: archinternmed.2010.423 [pii]10.1001/archinternmed.2010.423.

Gaugler JE, Duval S, Anderson KA, Kane RL. Predicting nursing home admission in the U.S: a meta-analysis. BMC Geriatrics. 2007; 19:7–13.

Gill TM, Gahbauer EA, Han L, Allore HG. Trajectories of disability in the last year of life. New England Journal of Medicine. 2010; 362:1173–1180. doi:362/13/1173 [pii] 10.1056/NEJMoa0909087. [PubMed: 20357280]

Gill TM, Robison JT, Tinetti ME. Difficulty and dependence: Two components of the disability continuum among community-living older persons. Annals of Internal Medicine. 1998; 128(2):96–101. [PubMed: 9441588]

Gill TM, Williams CS, Richardson ED, Berkman LF, Tinetti ME. A predictive model for ADL dependence in community-living older adults based on a reduced set of cognitive status items. Journal of the American Geriatrics Society. 1997; 45:441–445. [PubMed: 9100712]

Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. New England Journal of Medicine. 1995; 332:556–561. [PubMed: 7838189]

Hardy SE, Gill TM. Recovery from disability among community- dwelling older persons. Journal of American Medical Association. 2004; 291:1596–1602. [pii]. 10.1001/jama. 291.13.1596291/13/1596

Haung WW, Perera S, VanSwearingen J, Studenski S. Performance measures predict onset of activity of daily living difficulty in community-dwelling older adults. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. Journal of the American Geriatrics Society. 2010; 58:844–852.10.1111/j.1532-5415.2010.02820.x [PubMed: 20406319]

Hauser, RM.; Willis, RJ. Survey design and methodology in the Health and Retirement Study and the Wisconsin Longitudinal Study. In: Waite, L., editor. Aging, health, and public policy: Demographic and economic perspectives. New York: Population Council; 2004. p. 209-235.

Institute of Medicine. The future of disability in America. Washington, DC: National Academies Press; 2007.

Langa, K.; Kabeto, M.; Weir, D. Task 1 for report on race and cognitive impairment using HRS 2006. Ann Arbor, MI: University of Michigan; 2009.

Lewin Group. Individuals living in the community with chronic conditions and functional limitations: A closer look. Washington, DC: U.S. Department of Health and Human Services; 2010.

Min L, Yoon W, Mariano J, Wenger NS, Elliott MN, Kamberg C, Saliba D. The vulnerable elders-13 survey predicts 5-year functional decline and mortality outcomes in older ambulatory care patients. Journal of the American Geriatrics Society. 2009; 57:2070–2076. doi: JGS2497 [pii] 10.1111/j.1532-5415.2009.02497.x. [PubMed: 19793154]

Ohman EM, Granger CB, Harrington RA, Lee KL. Risk stratification and therapeutic decision making in acute coronary syndromes. Journal of American Medical Association. 2000; 284:876–878. doi: jco00116 [pii].

Sarkisian CA, Liu H, Gutierrez PR, Seeley DG, Cummings SR, Mangione CM. Modifiable risk factors predict functional decline among older women: A prospectively validated clinical prediction tool. The Study of Osteoporotic Fractures Research Group. Journal of the American Geriatrics Society. 2000; 48(2):170–178. [PubMed: 10682946]

Van Kan GA, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, Vellas B. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people. An International Academy on Nutrition and Aging (IANA) Task Force. Journal of Nutrition, Health & Aging. 2009; 13:881–889.

Viccaro LJ, Perera S, Studenski SA. Is timed up and go better than gait speed in predicting health, function, and falls in older adults? [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. Journal of the American Geriatrics Society. 2011; 59:887–892.10.1111/j. 1532-5415.2011.03336.x [PubMed: 21410448]

Table 1

Descriptive Statistics for Development and Validation Cohorts.

Variable	2/3rd Development cohort (*n* = 5,332)	1/3rd Validation cohort (*n* = 2,763)
Incident ADL dependency (weighted)	4.78	4.62
Age, mean (*SD*)	74.1 (6.7)	74.1 (6.8)
65–74, %	58.3	59.9
75–84, %	32.7	30.7
≥85+, %	9.0	9.3
Gender		
Female, %	57.5	58.7
Ethnicity		
Hispanic, %	7.0	7.9
Non-Hispanic Black, %	11.5	11.7
Non-Hispanic White, %	80.2	79.3
Non-Hispanic Other, %	1.3	1.2
Chronic conditions		
Hypertension, %	62.0	63.9
Diabetes, %	20.2	20.7
Heart disease not congestive heart failure, %	25.3	25.3
Congestive heart failure, %	3.6	3.1
Chronic lung disease, %	10.2	11.7
Arthritis, %	67.5	68.1
Cancer not skin, %	18.1	17.7
Stroke, %	6.0	6.0
Covinsky index score, mean (*SD*)	1.5 (1.4)	1.5 (1.4)
0, %	30.0	28.8
1, %	29.7	28.6
2, %	19.5	20.2
3, %	11.5	12.5
4, %	6.0	7.1
5–9, %	3.3	2.7
Covinsky items (age and diabetes shown above), mean (*SD*)		
Low body-mass index, %	7.7	7.8
Difficulty lifting 10 pounds, %	19.9	21.6
Difficulty walking several blocks, %	28.7	30.7
Difficulty with bathing or dressing, %	7.1	6.8
Need help managing money, %	1.9	1.9
Unable to name the vice president, %	9.0	9.4
Cognitive status, mean (*SD*)		
Working memory—series 7 subtraction (score = number of correct subtractions; range = 0 to 5)	3.6 (1.7)	3.5 (1.7)

Variable	2/3rd Development cohort (*n* = 5,332)	1/3rd Validation cohort (*n* = 2,763)
Speed of processing—counting backward from 20 (score = 2 if correct on first trial, 1 if correct on second trial and 0 if not correct either time; range = 0 to 2)	1.9 (0.4)	1.9 (0.4)
Orientation—month, day, year, weekday (range = 0 to 4)	3.8 (0.5)	3.8 (0.6)
Orientation indicator variable (2 or fewer correct), %	2.7	3.0
Short-term memory—immediate word recall (score = number of words recalled correctly; range = 0 to 10)	5.3 (1.6)	5.3 (1.5)
Immediate word recall indicator variable (2 or fewer words recalled), %	3.2	3.1
Short-term memory delayed word recall (score = number of words recalled correctly range = 0 to 10)	4.3 (1.8)	4.3 (1.7)
Delayed word recall indicator variable (three or fewer words recalled), %	32.1	32.0
Gait speed – number of meters per second (quartiles)	(n=2,316)	(n=1,190)
<.59 or unable to walk due to health reasons	25.0	26.3
>=.59 and <.74	24.2	21.1
>=.74 and <.91	24.7	25.1
>=.91	26.0	27.5
Indicator for being in slowest quartile, %	25.0	26.3

Note: ADL = activity of daily living; SD = standard deviation.

Table 2

Results of Logistic Regression With Backward Elimination of Interview Items, Four Cognitive Dimensions, and Gait Speed for Predicting Incident Activity of Daily Living Dependency in the Development Cohorts.[a]

	Primary interview (n=5,332)		Enhanced interview subsample (n=2,316)	
		without delayed recall	without gait speed	With gait speed
Variable	***OR* (95% CI)**	***OR* (95% CI)**	***OR* (95% CI)**	***OR* (95% CI)**
Age ≥ 80	3.08 [2.34, 4.05]	3.32 [2.53, 4.35]	3.53 [2.28, 5.44]	2.88 [1.84, 4.49]
Diabetes	1.41 [1.05, 1.91]	1.43 [1.06, 1.93]		
Difficulty walking several blocks	3.96 [2.96, 5.29]	4.05 [3.03, 5.40]	4.16 [2.63, 6.60]	3.30 [2.05, 5.32]
Difficulty with bathing or dressing	2.49 [1.78, 3.47]	2.52 [1.80, 3.51]	2.10 [1.18, 3.74]	1.84 [1.02, 3.31]
Need help managing money	2.31 [1.34, 4.00]	2.46 [1.43, 4.23]		
Orientation	2.57 [1.53, 4.32]	2.83 [1.69, 4.74]		
Short-term memory—immediate word recall	1.72 [1.03, 2.86]	2.13 [1.29, 3.50]	4.55 [2.26, 9.19]	3.68 [1.80, 7.54]
Short-term memory—delayed word recall	1.54 [1.16, 2.05]			
Gait Speed (slowest quartile vs. all others)				2.87 [1.79, 4.60]
c-statistic	0.821	0.815	0.812	0.834

Note:

[a]Included as candidate variables in the backward elimination were age ≥ 80, diabetes, difficulty lifting 10 pounds, difficulty walking several blocks, difficulty with bathing or dressing, needing help to manage money, inability to name vice president, working memory, speed of processing, immediate word recall, delayed word recall, and orientation.

Table 3

Results of Logistic Regression With Interview Items, Four Cognitive Dimensions, and Gait Speed for Predicting Incident Activity of Daily Living Dependency in the Validation Cohorts.

	Primary interview (n = 2,763)	**Enhanced interview subsample (n = 1,190)**
	without delayed recall	**Gait speed with primary interview items**
Variable	***OR* (95% CI)**	***OR* (95% CI)**
Age ≥ 80	2.63 [1.81, 3.81]	1.90 [1.01, 3.55]
Diabetes	1.49 [0.99, 2.23]	
Difficulty walking several blocks	5.68 [3.75, 8.61]	3.81 [1.97, 7.38]
Difficulty with bathing or dressing	1.53 [0.92, 2.54]	1.83 [0.80, 4.17]
Need help managing money	2.50 [1.14, 5.50]	
Orientation	3.14 [1.60, 6.15]	
Short-term memory—immediate word recall	2.71 [1.37, 5.35]	2.09 [0.66, 6.69]
Short-term memory—delayed word recall		
Gait speed (slowest quartile vs. all others)		2.27 [1.19, 4.31]
c-statistic	0.801	0.791

Table 4

Results of Logistic Regression of Brief Models With and Without Gait Speed, Validation Cohort.

Variable	Scoring of primary interview model indicators[a]	Primary interview model fit using indicator scoring (*n* = 2,763)	Scoring of enhanced interview model indicators[#]	Enhanced interview model fit using indicator scoring (*n* = 1,190)
Age ≥ 80	3		3	
Diabetes	1			
Difficulty walking several blocks	4		3	
Difficulty with bathing or dressing	3		2	
Need help managing money	2			
Orientation	3			
Short-term memory—immediate word recall	2		4	
Gait speed			3	
c-statistic		0.801		0.784

Note:

[a]Scoring determined by rounding to the nearest whole number the odds ratios obtained in analyses shown in Table 2.